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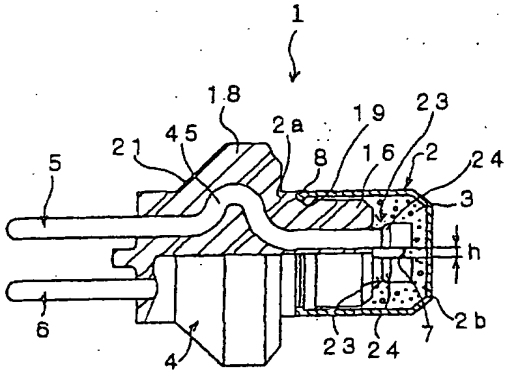
(54) SQUIB AND METHOD OF MANUFACTURE THEREOF

(57) The present invention relates to a squib used for a gas generator that operates an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system and to a producing method thereof. The invention provides a squib including a cup (2), an ignition agent (3) packed in the cup (2), a plug (4) to close an opening of the cup (2), two electrode pins (5, 6) inserted in the plug to extend through it, and a bridge wire (7) that is connected between the two electrode pins (5, 6) in the cup (2) and generates heat when electrically energized, wherein the two electrode pins (5, 6) are inserted in the plug (4) to extend through it in such a manner as to form projected portions (23) that are projected from one end of the plug on the cup side, wherein the bridge wire (7) is connected between the projected portions (23) of the electrode pins (5, 6), wherein the bridge wire (7) and the projected portions (23) are buried in the ignition agent (3), and wherein the bridge wire (7) and the ignition agent (3) are sealed in the cup (2) in the condition in which they have a certain contact pressure acting on each other. Also, the present invention provides a producing method thereof.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a squib used for a gas generator for an occupant's safety protecting system of an automobile, such as a seatbelt pretensioner and an airbag system.

Background Art

[0002] A seatbelt pretensioner and an airbag system are known as occupant protecting systems to protect occupants from the impact from a car crash. These seatbelt pretensionser and equivalent are operated by a large amount of gases supplied from the gas generator to protect the occupants. The gas generator includes a squib and a gas generating agent, so that the squib is rapidly ignited at a car crash, to ignite and burn the gas generating agent to thereby generate a large amount of gases.

[0003] To take an instance of the squib used for the gas generator, it comprises a cup to contain an ignition agent and a plug to be inserted in the cup to seal the ignition agent therein, and the cup and the plug are both formed of a plastic resin or equivalent. The plug has two electrode pins extending through it. The electrode pins are projected into the cup and are electrically connected to a bridge wire at one ends thereof. The bridge wire is covered with an ignitable agent contacting with the ignition agent. The ignitable agent comprises ignition sensitive material so that it can be ignited by generation of heat of the bridge wire, to ignite the ignition agent.

[0004] The squib is loaded on the gas generator so that it can be electrically energized via impact signals from crash sensors to cause generation of heat of the bridge wire. The bridge wire generating heat ignites the ignitable agent and in turn ignites the ignition agent to burn it. Then, the pressure and heat developed and generated by the burning of the ignition agent causes the ignition and combustion of the gas generating agent.

[0005] In the conventional ignition system of the resin squib, the bridge wire is made to generate heat to ignite the ignitable agent, followed by the ignition of the ignition agent, for the purpose of stabilizing the ignition sensitivity.

[0006] For this, in the conventional resin squib, the bridge wire need be covered with the ignitable agent. It is common that the bridge wire is dipped in the ignitable agent in numbers so that it can be covered with deposited ignitable agent. This causes increase in manufacturing costs as well as in working costs.

[0007] Also, the ignitable agent usually contains harmful heavy metal such as lead. From the environmental consciousness in recent years, the squib using no hazardous substance is being desired increasingly.

[0008] In addition, in recent years, cost reduction is being strongly demanded for the gas generator used for the seatbelt pretensioner or the airbag system, along with which cost reduction is being increasingly demanded for the squib also.

[0009] It is the object of the present invention to provide a squib that can be produced at a reduced cost and also is of environmentally friendly.

Disclosure of the Invention

[0010] A squib of the present invention is directed to a squib used for a gas generator that works to operate an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system. The squib of the present invention comprises a cup, an ignition agent packed in the cup, a plug to close an opening of the cup, two electrode pins inserted in the plug to extend through it, and a bridge wire that is connected between the two electrode pins in the cup and generates heat when electrically energized.

[0011] The two electrode pins are inserted in the plug to extend through it, so as to define projected portions that are projected from one end of the plug on the cup side. The bridge wire is connected between the projected portions of the electrode pins.

[0012] The bridge wire and the projected portions are buried in the ignition agent.

[0013] The bridge wire and the ignition agent are sealed in the cup in the condition in which they have a certain contact pressure acting on each other.

[0014] A producing method of the squib of the present invention is directed to a method of producing a squib used for a gas generator that works to operate an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system.

[0015] The producing method of the squib comprises the step of forming a plug by charging resin into a space between two paralleled electrode pins except opposite end portions thereof, as well as a space therearound, the step of connecting both ends of a bridge wire to projected portions of the electrode pins that are projected from one end of the plug, respectively, the step of inserting a portion of the plug on the bridge wire side into a cup, to hide and bury the bridge wire and the projected portions in the ignition agent packed in the cup, and the step of fittingly engaging the plug in the cup so that the bridge wire and the ignition agent can be sealed in the cup in the condition in which they have a certain contact pressure acting on each other.

[0016] According to the present invention thus constituted, since the bridge wire is buried in the ignition agent, the contact area between the bridge wire and the ignition agent can be increased. Also, when the ignition agent having a component that is ignited by generation of heat of the bridge wire is used, the ignition agent around the bridge wire can be ignited by generation of heat of the bridge wire caused by passage of electric current through the electrode pins. Since the bridge wire and the ignition agent are sealed in the cup in the condition

in which they have a certain contact pressure acting on each other, the ignition agent can be ignited stably only by the generation of heat of the bridge wire.

[0017] Since the bridge wire is connected between the projected portions of the electrode pins and is positioned at a higher lever than the plug, it can be adjusted to have a certain contact pressure in the assembling process in which the plug is inserted in the cup to fittingly engage the plug and the cup with each other.

[0018] Further, it is preferable that the projected portions of the electrode pins are provided, at ends thereof, with planate deposition surfaces extended along the axes of the electrode pins and arranged in parallel with a predetermined fixed clearance h in the substantially same plane, and both ends of the bridge wire are connected to the deposition surfaces, respectively.

[0019] With the constitution above, a substantial length of the bridge wire is determined by the clearance h between the deposition surfaces. If the connecting position of the bridge wire is in the deposition surface, any bridge wire will have a substantial length h, so that the substantial fixed length h of the bridge wire can be obtained. Thus, the bridge wire can be connected to the electrode pins with ease, without enhancing the precision of the connecting position of the bridge wire, and a prescribed resistance value of the bridge wire can also be secured.

[0020] Additionally, it is preferable that utmost end portions of the projected portions of the electrode pins are folded back in such a manner as to cover connected portions of the bridge wire. By virtue of this constitution, the connected portions of the bridge wire can be prevented from being detached off due to the contact resistance with the ignition agent in the process that the bridge wire is hidden in the ignition agent to be buried therein.

[0021] Also, it is preferable that the bridge wire is connected between the projected portions in the loosened state in which no substantial tensile force is applied therebetween and then is sealed in the cup.

[0022] By virtue of this constitution, a contact resistance of the ignition agent against the bridge wire can be reduced in the process that the bridge wire is hidden in the ignition agent to be buried therein.

[0023] It is preferable that a loading density of the ignition agent in the cup is adjusted to fall within a range of between 2 mg/mm^3 and 4 mg/mm^3 so that the bridge wire and the ignition agent are sealed in the cup in the condition in which they have a certain contact pressure acting on each other. Further, it is preferable that the ignition agent has a component that is ignited by generation of heat of the bridge wire and is in the form of power or granule. In addition, it is preferable that the ignition agent has zirconium as a component. These enable the ignition agent to be ignited stably only by the generation of heat of the bridge wire.

Brief Description of the Drawings

[0024] FIG. 1 is a partial cross section of a squib of the present invention as viewed from the front, FIG. 2 is an exploded view of the squib shown in FIG. 1, FIG. 3 is a partial cross section of a plug of the squib shown in FIG. 1 as viewed from the top, FIG. 4(a), FIG. 4(b), FIG. 4(c) and FIG. 4(d) are diagrams illustrating the production method of the squib, FIG. 4(a) and FIG. 4(b) are front views of the squib; FIG. 4(c) is a sectional view of the same as viewed from the top; and FIG. 4(d) is a sectional view of the same as viewed from the front, FIG. 5 (a), FIG. 5(b), FIG. 5(c) and FIG. 5(d) are diagrams illustrating the production method of the squib, FIG. 5(a), FIG. 5(b) and FIG. 5(c) are partial cross sections of the squib as viewed from the front; and FIG. 5(d) is a sectional view of the same as viewed from the top, FIG. 6 (a), FIG. 6(b) and FIG. 6(c) are diagrams illustrating the production method of the squib and are partial cross sections of the same as viewed from the front, FIG. 7(a) shows a connected state of the bridge wire of the conventional squib; and FIG. 7(b) shows a connected state of the bridge wire of the squib of the present invention, FIG. 8 is a partial cross section of another squib of the present invention as viewed from the front, FIG. 9 is an exploded view of the squib shown in FIG. 8, and FIG. 10 is a partial cross section of the gas generator using the squib of the present invention as viewed from the front.

Best Mode for Carrying out the Invention

[First Embodiment]

[0025] The first embodiment will be described below with reference to FIGS. 1 through 3, FIG. 7(a) and FIG. 7(b).

[0026] A squib 1 shown in FIG. 1 comprises a cup 2, an ignition agent 3, a plug 4, two electrode pins 5, 6 and a bridge wire 7. The squib 1 is tried to reduce cost by forming the cup 2 and plug 4 of resin.

[0027] The cup 2 is formed by a bottom 2b and a cylindrical portion and is packed with the ignition agent 3. The cup 2 has, at an end thereof on the opening 2a side, a convexity 8 formed around an inside surface thereof, so that when the plug 4 is inserted in the cup 2, the convexity 8 of the cup 2 is fitted in a fitting groove 19 formed in the plug 4 at a specified position thereof, to maintain the plug 4 at a predetermined position in the cup 2.

[0028] The cup 2 is formed of material comprising resins, such as PBT (polybutylene terephthalate), PET (polyethylene terephthalate), PA6 (nylon 6), PA66 (nylon 66), PPS (polyphenylene sulfide) and PPO (polyphenylene oxide), combined with reinforcement such as glass fiber.

[0029] The plug 4 comprises a cylindrical portion 16 to be inserted in the cup 2 and a flanged portion 18 projecting radially outwardly at one end of the cylindrical

portion 16 to extend continuously to the cylindrical portion 16. The cylindrical portion 16 has an annular fitting glove 19 formed around the cylindrical portion 16 in which the convexity 8 of the cup 2 is fitted. The flanged portion 18 has a tapered surface 21 that decreases in diameter toward the opposite side to the cylindrical portion 16. The plug 4 is formed of material comprising resins, such as PBT, PET, PA6, PA66, PPS and PPO, combined with reinforcement such as glass fiber.

[0030] The two electrode pins 5, 6 are arranged in parallel with the axis of the cylindrical portion 16 of the plug 4 to extend through the plug 4 and project out from both ends of the plug 4. Each of the electrode pins 5, 6 has a curved portion 45 curved outwardly within the flanged portion 18. The electrode pins 5, 6 are formed from a single conductive round rod of e.g. stainless steel, an iron-nickel alloy, and the like metal.

[0031] The electrode pins 5, 6 have deposition surfaces 24 formed continuously thereto at their projected portions 23 projected out axially from the other end of the cylindrical portion 16, respectively. The deposition surfaces 24 are flat surfaces extended along the axes of the electrode pins 5, 6 and are arranged in parallel with each other with a predetermined fixed clearance h in the substantially same plane. These flat surfaces can be easily formed by pressing the ends of the projected portions 23 of the electrode pins 5, 6 radially by means of a press molding and the like.

[0032] The bridge wire 7 is bridged between the deposition surfaces 24 so as to vertically extend across the clearance h therebetween at the ends of the projected portions 23 in a loosened state in which no substantial tensile force is applied therebetween. Then, in the condition in which the bridge wire 7 is kept in its loosened state in which no substantial tensile force is applied therebetween, the opposite ends of the bridge wire are deposited on their related deposition surfaces 24 by welding and the like, as shown in FIG. 3. The welded portions 25 of the bridge wire 7 is covered with a folded-back portion 24a formed by folding back the ends of the deposition surfaces 24 which are the utmost ends of the projected portions 23.

[0033] This specific structure of the bridge wire 7 connecting between the deposition surfaces 24 can permit a substantial length of the bridge wire 7 to be determined by the clearance h between the deposition surfaces 24, as shown in FIG. 7(b). Any bridge wire 7 bridged between the deposition surfaces 24 so as to vertically extend across the clearance h will have a substantial length of h at any two connecting locations in the deposition surfaces 24. This can provide the result that the substantial fixed length h of the bridge wire can be secured without improving the precision of the connecting position of the bridge wire 7. Thus, the bridge wire 7 can be connected to the electrode pins 5, 6 with ease and a prescribed resistance value of the bridge wire 7 can also be secured.

[0034] In contrast to this, when the bridge wire is connected between cut surfaces of the electrode pins 5, 6, as shown in FIG. 7(a), the distance L1, L2 between the electrode pins 5, 6 varies depending on the locations at which the bridge wire 7 is welded and, thus, the substantial length of the bridge wire 7 varies also. Consequently, the substantial predetermined length of the bridge wire 7 cannot be obtained unless the locations at which the opposite ends of the bridge wire 7 are welded are adjusted with accuracy.

[0035] Additionally, the constitution that the bridge wire 7 is connected between the deposition surfaces 24 in the loosened state in which no substantial tensile force is applied therebetween, as shown in FIG. 2, can provide the result that a contact resistance of the ignition agent 3 against the bridge wire 7 can be reduced in the process that the bridge wire 7 is hidden in the ignition agent 3 to be buried therein.

[0036] Also, the constitution that the welded portions 25 of the bridge wire 7 are covered with the folded-back portions 24a at the ends of the deposition surfaces 24 can provide the result of preventing the welded portions 25 of the bridge wire 7 from being detached off due to the contact resistance with the ignition agent 3 in the process that the bridge wire 7 is hidden in the ignition agent 3 to be buried therein.

[0037] The generation of heat of the bridge wire 7 is caused by passage of electric current through the electrode pins 5, 6 shown in FIG. 1. The resistance value per unit length of the bridge wire 7 [Ω/mm] is set at a predetermined value so that a heating value of the bridge wire large enough to ignite the ignition agent 3 can be obtained.

[0038] The predetermined resistance value [Ω/mm] is determined with reference to a cross section form of the bridge wire 7, a thickness thereof, a value of the electric current [A] to be passed through the electrode pins 5, 6, etc.. A material having the strength to prevent the bridge wire 7 from being cut when the plug 4 is inserted into the cup 2, as well as the predetermined resistance value [Ω/mm], is selected as the material of the bridge wire 7. For example, the bridge wire 7 is formed of a nickel-chromium alloy wire rod excellent in generation of heat and strength.

[0039] Additionally, the bridge wire 7 is buried in the ignition agent 3 so that it can have an increased contact area with the ignition agent 3 to ignite the ignition agent 3 effectively.

[0040] The material having zirconium (Zr), tungsten (W), and potassium perchlorate ($KClO_4$) as components of the ignition agent and using fluororubber, cellulose nitrate and the like as a binder is preferably used as the ignition agent 3 packed in the cup 2. A ratio of composition among zirconium, tungsten, and potassium perchlorate is determined so that the ignition agent can fully be ignited by the generation of heat of the bridge wire 7. For instance, the ratio of composition of $Zr:W:KClO_4$ is set to be 3:3.5:3.5 by weight. The ignition agent 3 is preferably formed into a powdery form or granular form,

for increasing its contact area with the bridge wire 7 and also preventing cutting of the bridge wire 7 when the plug 4 is inserted in the cup 4.

[0041] The seatbelt pretensioner or equivalent to protect the occupants in the automobile must be operated within a few milliseconds (ms) from the car crash. From this constraint, the squib that works to ignite and burn the gas generating agent packed in the gas generator is also required to have the sensitivity to ignite within a few milliseconds (ms). Consequently, the loading density of the ignition agent loaded in the cup 2 is set to be in the range of between 2mg/mm^3 and 4mg/mm^3 so that the ignition agent can be sealed in the cup at a predetermined contact pressure between the bridge wire 7 and the ignition agent 3, whereby the ignition agent is stably ignited by the electric energization of "a current value (A) for the bridge wire × a few milliseconds (ms)".

[0042] In order for the ignition agent to have the loading density of between 2mg/mm^3 and 4mg/mm^3, it is preferable that the volume to contain in the cup is set to be in the range of between 15mg/mm^3 and 120mg/mm^3 and an amount of ignition agent is in the range of between 50mg and 480mg. Additionally, it is preferable that the bridge wire has a diameter of between Ø 20 μm and 29 μm and a length of between 0.5mm and 1.2mm.

[0043] Before the bridge wire 7 is hidden in the ignition agent 7, together with the projected portions 23, the loading density (apparent specific gravity) of the ignition agent 3 is preferably adjusted to be 1.3 mg/mm^3 or less, to enable the bridge wire 7 to effectively be prevented from being cut off when hidden in the ignition agent. After the bridge wire 7 is hidden in the ignition agent 3, the plug 4 is further inserted deep into the cup 2, so that the loading density of the ignition agent 3 is increased up to the range between 2mg/mm^3 and 4mg/mm^3, or optimally 3mg/mm^3. Then, the plug 3 is fittingly engaged in the cup 2 and is kept in that state.

[0044] These specific conditions can ensure the operating time of a few milliseconds required for the gas generator of the occupant protecting system, such as the seatbelt pretensioner or equivalent, to operate.

[0045] In the squib thus constructed, when the electric current is applied between the electrode pins 5, 6, the bridge wire 7 generates heat within a few milliseconds, and as such can allow the ignition agent 3 to stably ignite and burn by the generation of heat only. Then, the internal pressure of the cup 2 is increased by the combustion of the ignition agent 3, to burst the bottom 2b of the cup 2. The flame of the ignition agent 3 is spouted from the outside of the squib into the gas generator.

[0046] Thus, the squib of the present invention enables the ignition agent 3 to be ignited and burnt without any ignitable agent containing harmful substance being used for the bridge wire 7. Thus, since there is no need to provide any ignitable agent containing harmful substances, the squib of low costs as well as of environmentally friendly can be provided.

[0047] Referring now to FIGS. 4 through 6, the production method of the squib 1 of the present invention will be described.

[0048] The squib 1 of the present invention is produced through the following processes. In FIGS. 4 through 6, the same reference numerals are applied to functionally corresponding members to those in FIGS. 1 through 3.

(1) Process of forming the two electrode pins:

[0049] As shown in FIG. 4(a), a single conductive rod 40 comprising stainless-steel or iron-nickel alloy is prepared. The conductive rod 40 is folded into the U-shaped form by the press molding and the like. Two parallel electrode pins 5, 6 having straight-line portions and a folded portion 46 are formed. The electrode pins 5, 6 remain connected to each other at one ends thereof through the U-shaped folded portion 46.

[0050] Further, the electrode pins 5, 6 are formed to have symmetrical curved portions 45 at locations of the straight-line portions by the press molding and the like. Thus, the two paralleled electrode pins 5, 6 having the curved portions 45 and the first and second straight-line portions 5a, 6a, 5b, 6b sandwiching the curved portions 45 therebetween are formed. The electrode pins 5, 6 still remains connected to each other through the U-shaped folded portion 46.

(2) Process of forming the plug 4:

[0051] As shown in FIGS. 4(b) and 4(c), the plug 4 is molded by use of two split molds 41, 42 having first and second continuous molding spaces 43, 44 corresponding to the cylindrical portion 16 and the flanged portion 18 of the plug 4.

[0052] The first straight-line portions 5a, 6a of the electrode pins 5, 6 are arranged in parallel along the axis of the first molding space 43. The curved portions 45 of the electrode pins 5, 6 are arranged in the second molding space 44. End portions of the first and second straight-line portions 5a, 6a, 5b, 6b of the respective electrode pins 5, 6 are projected from the first and second molding spaces 43, 44. In this state, resin is injected into the first and second molding spaces 43, 44, so that the molds are filled with the resin.

[0053] Sequentially, after the resin filled in the molds 41, 42 is cured, the electrode pins 5, 6 and cured resin is taken out of the molds 41, 42 to thereby produce the plug 4 shown in FIG. 4(d). The electrode pins 5, 6 and the plug 4 are formed as a unit, and the electrode pins extend through the plug 4 and project out from the opposite ends of the plug.

(3) Process of forming deposition surfaces 24 of the electrode pins 5, 6:

[0054] As shown in FIG. 5(a), the folded portion 46 is cut off from the first straight-line portions 5a, 6a of the

electrode pins 5, 6 projecting from the cylindrical portion 16 of the plug 4, to separate the electrode pins 5, 6 from each other. In this process, the folded portion 46 is cut off, leaving lengths required for the deposition surfaces 24 to be formed on the ends of the projected portions 23 of the electrode pins 5, 6 projecting from the cylindrical portion 16 of the plug 4.

[0055] Sequentially, as shown in FIG. 5(b), the ends of the projected portions 23 are pressed radially by means of the press molding and the like, to form the deposition surfaces 24 extended along the axes of the electrode pins 5, 6. In this press molding process, precision of a degree of roughness of the deposition surfaces 24 and a degree of parallelism therebetween is ensured so that the deposition surfaces 24 can be arranged in parallel with each other with a predetermined fixed clearance h in the same plane.

(4) Process of depositing the bridge wire 7:

[0056] As shown in FIG. 5(c), the both ends of the bridge wire 7 are deposited on their respective deposition surfaces 24 at the ends of the projected portions 23 by welding and the like.

[0057] The bridge wire 7 is bridged between the deposition surfaces 24 so as to vertically extend across the clearance h therebetween and the both ends of the bridge wire are deposited on the deposition surfaces 24 at the projected portions 23 in a loosened state in which no substantial tensile force is applied therebetween.

[0058] In this process, since the deposition surfaces 24 are arranged in parallel with each other with a predetermined fixed clearance h in the same plane, the substantial length of the bridge wire 7 does not vary even when the both ends of the bridge wire are deposited at any two locations in the deposition surfaces 24.

[0059] For instance, the bridge wire 7 is deposited at the locations on the deposition surfaces 24 with a distance of 0.5-4.0mm from the end of the plug 4.

[0060] Further, as shown in FIG. 5(d), the ends of the deposition surfaces 24 of the projected portions 23 are folded back to cover the welded portions 25 of the bridge wire 7, so that the welded portions 25 of the bridge wire 7 are covered with the folded-back portion 24a.

(5) Process of burying the bridge wire 7 and the projected portions 23 in the ignition agent 3:

[0061] As shown in FIG. 6(a), the cup 2 containing the ignition agent 3 is prepared. The cup 2 is formed of material comprising resins, such as PBT, PET, PA6, PA66, PPS and PPO, combined with reinforcement such as glass fiber and is formed into a cup-like shape at the same time as or prior to the processes mentioned above. The powdered or granulated ignition agent 3 is sealed in the cup 2 in a non-compressed state.

[0062] Then, as shown in FIG. 6(b), the cylindrical portion 16 of the plug 4 is inserted into the cup 2, so that the projected portions 23 and the bridge wire 7 are hidden in the ignition agent 3 and buried therein.

[0063] In this process, since the welded portions 25 of the bridge wire 7 are in the state of being encircled by the folded-back portions 24a, they are prevented from being detached off from the deposition surfaces by the frictional resistance between the bridge wire 7 and the ignition agent 3.

[0064] After the projected portions 23 and the bridge wire 7 are buried in the ignition agent 3, the cylindrical portion 16 of the plug 4 is inserted into the cup 2.

(6) Process of fitting the plug 4 into the cup 2:

[0065] As shown in FIG. 6(b), the plug 4 is pressed further toward the bottom 2b of the cup 2 to gradually increase the loading density of the powdered or granulated ignition agent 3.

[0066] In this process, since the bridge wire 7 is configured to project from the plug 4, together with the projected portions 23, the contact pressure of the bridge wire with the ignition agent 3 is gradually increased in the cup 2. However, since the bridge wire 7 is bridged between the electrode pins 5, 6 in the loosened state in which no substantial tensile force is applied therebetween, the bridge wire 7 is prevented from being cut off under the increased contact pressure when pressed into the cup 2.

[0067] Then, as shown in FIG. 6(c), the convexity 8 of the cup 2 is fitted in the fitting groove 19 of the plug 4 and thereby the plug 4 is held in a specified position of the cup 2. In this process, the loading density of the ignition agent 3 in the cup 2 comes to be a desired loading density, so that the bridge wire 7 is put into contact with the ignition agent 3 with a desired contact pressure.

[0068] Through the processes above, the squib 1 comprising the plug 2 and the cup 2 which are formed as a unit is assembled.

[0069] It should be noted that the constitution that the bridge wire 7 and the ignition agent 3 are sealed with a specific contact pressure therebetween is not indispensable for the squib of the present invention. For example, when the composition of the ignition agent 3 is changed to enhance the ignition sensitivity, so that the ignition agent 3 is stably ignited by the electric energization of "a current value (A) for the bridge wire × a few milliseconds (ms)", there is no need to seal the bridge wire 7 and the ignition agent 3 in the condition in which a specific contact pressure is produced therebetween.

[0070] Also, while the squib 1 of the present invention as illustrated above uses the cup 2 made of resin, another cup, such as a cup made of metal and a double-structure cup made of metal and resin, may alternatively be used.

[0071] Further, while the squib 1 of the present invention as illustrated has the constitution that the welded portions 25 of the bridge wire 7 is protected by a folded-back portion 24a formed by folding back the ends 24a

of the deposition surfaces 24 which are the utmost ends of the projected portions 23 of the electrode pins 5, 6, if the bridge wire 7 is strong enough to withstand the contact resistance and contact pressure with the ignition agent 3, the ends of the deposition surfaces 24 need not necessarily be folded back.

[Second Embodiment]

[0072] The second embodiment will be described below with reference to FIGS. 8 and 9. In FIGS. 8 and 9, the same reference numerals are applied to functionally corresponding members to those in FIGS. 1 and 2.

[0073] The difference between FIGS. 8 and 9 and FIGS. 1 and 2 is in the configuration of a cup 71 and a plug 72.

[0074] The cup 71 of a squib 31 comprises a cylindrical portion 71c and a stepped portion 71d having an increased diameter at an opening 71a side of the cup and extending continuously from the cylindrical portion 71c. The cylindrical portion 71c has an annular fitting groove 32 formed around an inner surface thereof and a bursting portion 33 having a reduced thickness formed at the bottom 71b. The cylindrical portion 71c has an inner surface extending along the contour of a cylindrical portion 72a of the plug 72 mentioned later, and the stepped portion 71d having an increased diameter has an inner surface extending along the contour of a flanged portion 72b of the plug 72 as mentioned later.

[0075] The plug 72 of the squib 31 is a stepped cylindrical member having a corresponding contour to close contact with the inner surface of the stepped cup 71. The plug 72 comprises the cylindrical portion 72a and a flanged portion 72b projecting radially outwardly at one end of the cylindrical portion 72a to extend continuously to the cylindrical portion 72a. A convexity 34 to be fitted in the annular fitting groove 32 of the cup 71 is formed around an outer surface of the cylindrical portion 72a.

[0076] The squib 31 is assembled in the following steps. The plug 72 is inserted into the cup 71 from a portion thereof on the bridge wire 7 side. The projected portions 23 and bridge wire 7 projecting from the cylindrical portion 72a of the plug 72 are hidden in the ignition agent 3 packed in the cap 71, while the cylindrical portion 72a of the plug 72 is inserted into the cup 71. Sequentially, the plug 72 is pressed further toward the bottom 71b side of the cup 71 to gradually increase the loading density of the powdered or granulated ignition agent 3. When the plug 72 is pressed into position in the cup 71, in other words, when the ignition agent comes to have a certain loading density, the convexity 34 of the plug 72 is fitted into the fitting groove 32 of the cup 71. Then, the stepped portion 71b of the cup 71 comes into close contact with the flanged portion 72b of the plug 72, so that the cylindrical portion 71c of the cup 71 is put in close contact with the cylindrical portion 72a of the plug 72. Thus, the cup 71 and the plug 72 are engaged with each other in the specified position to form the united squib 31.

[0077] The squib of the second embodiment illustrated above can produce the same effect as the squib 1 shown in FIGS. 1 and 2. Besides, the plug 72 and the cup 71 are put in close contact with the cup 71 in a range from the cylindrical portion 71c to the opening 71a of the cup 71, so that the sealing performance is enhanced by the increased contact area between the plug 72 and the cup 71. As a result of this, the leakage of water or air into the space therebetween can be prevented.

[Gas generator]

[0078] Next, the gas generator G to which the squib 1 of the present invention is applicable will be described.

[0079] The gas generator of FIG. 10, which works to operate the seatbelt pretensioner of an automobile, comprises the squib 1, a holder 52, a gas generating agent 61 and a housing 62.

[0080] The holder 52 is a holder for fitting the squib 1 therein. The holder comprises a cylindrical member having, in the inner surface, a first stepped portion 58 serving as a fitting seat for the squib 1 and a second stepped portion 59 to close contact with the squib 1 in the range from the top of the flanged portion 18 to a part of the tapered surface 21. The holder 52 has two spaces divided by a boundary of the fitting seat 58, the two spaces being formed by a space 55 for containing the flanged portion 18 of the squib 1 on the second stepped portion 59 side and a space 56 for containing the electrode pins 5, 6 on the opposite side.

[0081] A seal ring 57 is disposed on the fitting seat 58. The squib 1 is inserted into the holder 52 from the second stepped portion 59 side and is seated on the fitting seat 58, such that the tapered surface 21 of the flanged portion 18 is brought into abutment with seal ring 57. The holder 52 has a first caulked portion 54 caulked along the configuration of the flanged portion 18 of the squib 1 at an end thereof on the side on which the squib 1 is inserted. The holder 52 contains the electrode pins 5, 6 in the space 56 at the opposite side to the fitting seat 58.

[0082] The housing 62 is a bottomed cylindrical housing, made of metal, for containing the squib 1 and the gas generating agent 61. The housing 62 has, at its bottom 62b, gas discharging holes 62a formed to discharge the gas generated by the combustion of the gas generating agent 61 from the housing 62 of the gas generator G toward the seatbelt pretensioner at the outside. The gas discharging holes 62a are closed by a thin film-like burst plate 63 made of aluminum or equivalent.

[0083] A portion of the holder 52 on the side on which the squib 1 is projected is inserted into the housing 62. An opening of the housing 62 is closed by the holder 52. The holder 52 has a second caulked portion 53 caulked along the opening of the housing 62 around the periphery of the holder 52.

[0084] The gas generator G thus constructed permits

the ignition agent 3 to be ignited and burnt by the generation of heat of the bridge wire 7 caused by the passage of electric current through the electrode pins 5, 6 of the squib 1. The gas generating agent 61 is ignited and burnt by the flame spouting from the squib 1 to generate a large amount of gases. Sequentially, the large amount of gases generated in the housing 62 produces an increased inner pressure of the housing and thereby the burst plate 63 is broken. Then, the gases are discharged from the gas discharging holes 62a to the outside of the gas generator G and are led into the seat pretensioner. Then, the seatbelt pretensioner is operated by the high pressure gas to tighten the seatbelt.

[0085] When the operation of the squib is ensured within a few milliseconds (ms), the gas generating agent 61 of the gas generator G can be ignited and burnt within a few milliseconds (ms). Hence, the pretensioner can be operated within a few milliseconds (ms) from the crash.

[0086] Thus, when the squib 1 of low price is used to the gas generator G, the manufacturing costs of the gas generator G itself can also be reduced.

[0087] It is to be noted that the squib of the present invention is also applicable to gas generators that work to expand and inflate the airbag system at a car crash. These gas generators include those intended for a driver's seat, a passenger's seat or a lateral crash. They permit the airbag system to be expanded and inflated by the gas generated by the combustion of the gas generating agent. The squib is loaded in the housing of the gas generator. Also, the gas generating agent, a filter, and the others are also arranged in the housing. The gas generating agent is burnt directly by the flame from the squib or indirectly through an enhancer agent, to thereby generate a large amount of gases to expand and inflate the airbag system.

[Example]

[0088] The test was conducted to examine that the squib of the present invention can reliably ignite the ignition agent 3 by the electric energization of "a current value (A) for the bridge wire × a few milliseconds (ms)".

[0089] A powdered or granulated ignition agent containing zirconium as the components was used, and the squib having the loading density of from 2 mg/mm^3 or more to 4 mg/mm^3 or less was assembled and provided by adequately selecting a volume to contain of the cup (mm^3), an amount of ignition agent loaded (mg), a diameter of the bridge wire Ø (μm), and a length of the bridge wire (mm).

[0090] Specifically, in order for the ignition agent to have the loading density of 2 mg/mm^3, the volume to contain in the cup 2 of 120 mm^3 and the amount of ignition agent 3 loaded of 240 mg were selected. Also, in order for the ignition agent 3 to have the loading density of 4 mg/mm^3, the volume to contain in the cup 2 of 30 mm^3 and the amount of ignition agent 3 loaded of 120 mg were selected. Further, in order for the ignition agent 3 to have the loading density of 3 mg/mm^3, the volume to contain in the cup 2 of 30 mm^3 and the amount of ignition agent 3 loaded of 90 mg were selected.

[0091] These squibs were energized in a 10cc container. The change of the inner pressure of the container with time was measured. It was confirmed from the measurement results that all squibs were ignited within a few milliseconds (ms).

Capability of Exploitation in Industry

[0092] Since the squib of the present invention permits the ignition agent to stably ignite, without any need to cover the bridge wire with the ignitable agent containing a harmful substance, to ensure the operation of the gas generator of the occupant protecting system, such as a seatbelt pretensioner and an airbag system, the squib can be produced at a reduced cost and is optimum as the squib of environmentally friendly.

Claims

1. A squib used for a gas generator that works to operate an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system, the squib comprising:

   a cup (2);
   an ignition agent (3) packed in the cup (2);
   a plug (4) to close an opening of the cup (2);
   two electrode pins (5, 6) inserted in the plug to extend through it; and
   a bridge wire (7) that is connected between the two electrode pins (5, 6) in the cup (2) and generates heat when electrically energized,
   the bridge wire (7) being buried in the ignition agent (3).

2. The squib according to Claim 1, wherein the bridge wire (7) and the ignition agent are sealed in the cup (2) in the condition in which they have a certain contact pressure acting on each other.

3. The squib according to Claim 2, wherein a loading density of the ignition agent (3) in the cup (2) is adjusted to fall within a range of between 2 mg/mm^3 and 4 mg/mm^3 so that the bridge wire and the ignition agent are sealed in the cup in the condition in which they have a certain contact pressure acting on each other.

4. The squib according to Claim 1 or 2, wherein the ignition agent (3) has a component that is ignited by generation of heat of the bridge wire (7) and is in the form of power or granule.

5. The squib according to Claim 1 or 2, wherein the ignition agent (3) has zirconium as a component.

6. A squib used for a gas generator that works to operate an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system, the squib comprising:

a cup (2);
an ignition agent (3) packed in the cup (2);
a plug (4) to close an opening of the cup (2);
two electrode pins (5, 6) inserted in the plug to extend through it; and
a bridge wire (7) that is connected between the two electrode pins (5, 6) in the cup (2) and generates heat when electrically energized,

wherein the two electrode pins (5, 6) are inserted in the plug (4) to extend through it, so that projected portions (23) are formed projecting from one end of the plug (4) on the cup side;

wherein the bridge wire (7) is connected between the projected portions (23) of the electrode pins (5, 6);

wherein the bridge wire (7) and the projected portions (23) are hidden in the ignition agent (3); and

wherein the bridge wire (7) and the ignition agent (3) are sealed in the cup (2) in the condition in which they have a certain contact pressure acting on each other.

7. The squib according to Claim 6, wherein the projected portions (23) of the electrode pins (5, 6) are provided, at ends thereof, with planate deposition surfaces (24) extended along the axes of the electrode pins (5, 6) and arranged in parallel with each other with a predetermined fixed clearance h in the substantially same plane; and wherein both ends of the bridge wire (7) are connected to the deposition surfaces (24), respectively.

8. The squib according to Claim 6 or 7, wherein utmost end portions (24a) of the projected portions (23) of the electrode pins (5, 6) are folded back in such a manner as to cover connected portions (25) of the bridge wire (7).

9. The squib according to Claim 6 or 7, wherein the bridge wire (7) is connected between the projected portions (23) of the electrode pins (5, 6) in a loosened state in which no substantial tensile force is applied therebetween and then is sealed in the cup (2).

10. The squib according to Claim 6 or 7, wherein a loading density of the ignition agent (3) in the cup (2) is adjusted to fall within a range of between 2 mg/mm^3 and 4 mg/mm^3 so that the bridge wire and the ignition agent are sealed in the cup in the condition in which they have a certain contact pressure acting on each other.

11. The squib according to Claim 6 or 7, wherein the ignition agent (3) has a component that is ignited by generation of heat of the bridge wire (7) and is in the form of power or granule.

12. The squib according to Claim 6 or 7, wherein the ignition agent (3) has zirconium as a component.

13. A method of producing a squib used for a gas generator that works to operate an occupant protecting system of an automobile, such as a seatbelt pretensioner and an airbag system, the method comprising:

the step of forming a plug (4) by charging resin into a space between two paralleled electrode pins (5, 6) except opposite end portions thereof, as well as a space therearound;
the step of connecting both ends of a bridge wire (7) to projected portions (23) of the electrode pins (5, 6) that are projected from one end of the plug (4), respectively;
the step of inserting a portion of the plug (4) on the bridge wire (7) side into a cup (2), to bury the bridge wire (7) and the projected portions (23) in the ignition agent (3) packed in the cup (2); and
the step of fittingly engaging the plug (4) and the cup (2) with each other so that the bridge wire (7) and the ignition agent (3) can be sealed in the cup (2) in the condition in which they have a certain contact pressure acting on each other.

14. The producing method of the squib according to Claim 13, wherein a loading density of the ignition agent (3) is adjusted to fall within a range of between 2 mg/mm^3 and 4 mg/mm^3, whereby the bridge wire (7) and the ignition agent (3) are sealed in the cup with a certain contact pressure.

15. The producing method of the squib according to Claim 13, wherein the ignition agent (3) having a component that is ignited by generation of heat of the bridge wire (7) and being in the form of power or granule is used.

FIG. 1

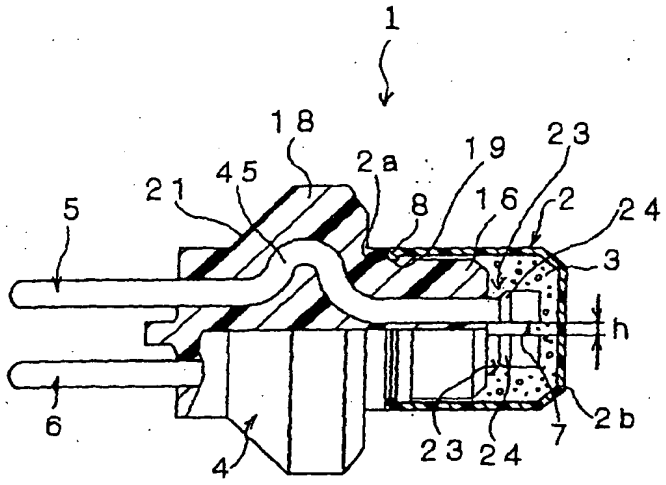
1
18
19
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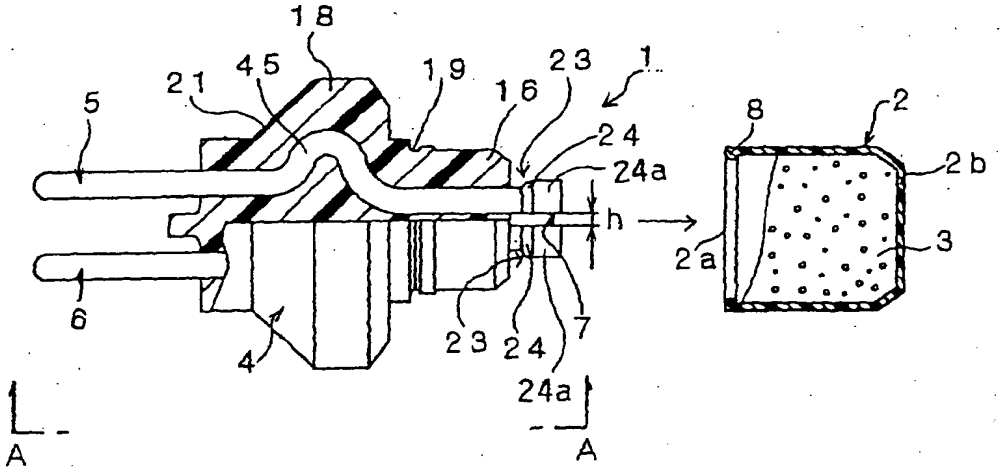
FIG. 2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2a
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24a
A
A

FIG. 3

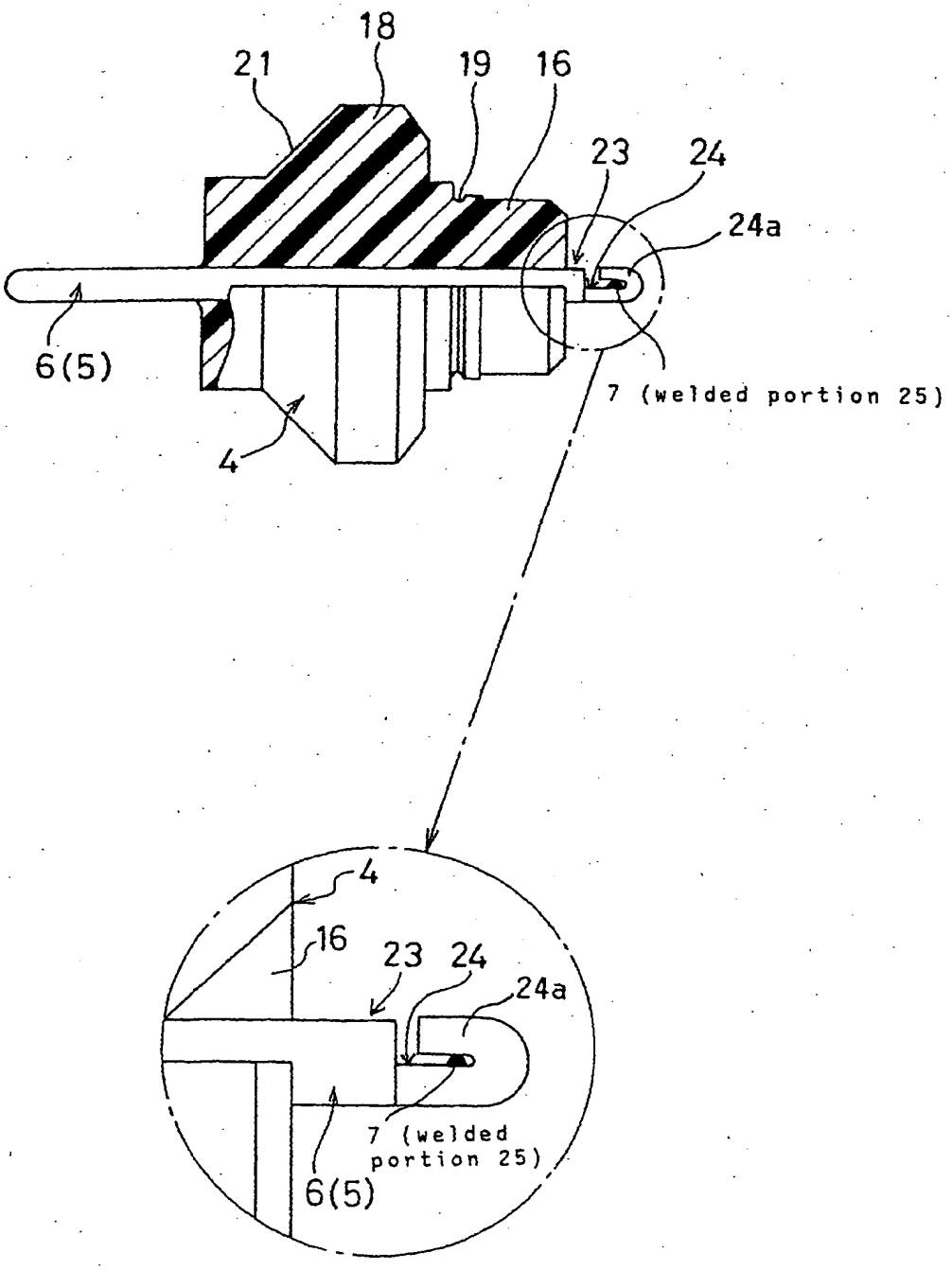

18
21
19
16
23
24
24a
6(5)
7 (welded portion 25)
4
4
16
23
24
24a
7 (welded portion 25)
6(5)

FIG. 4(a)

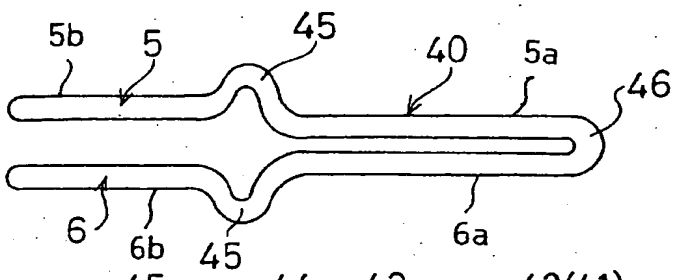


FIG. 4(b)

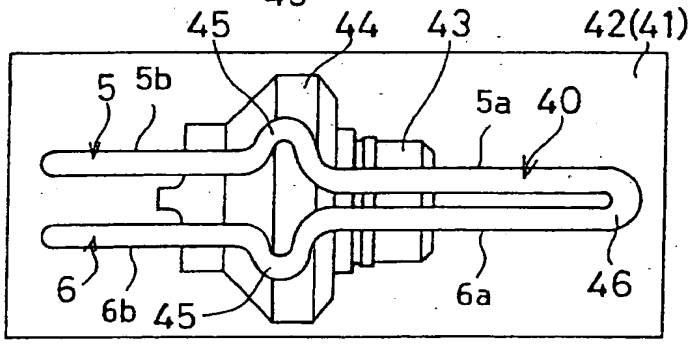


FIG. 4(c)

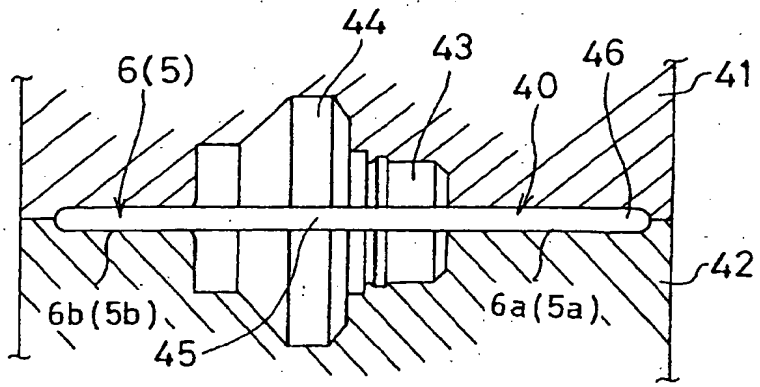


FIG. 4(d)

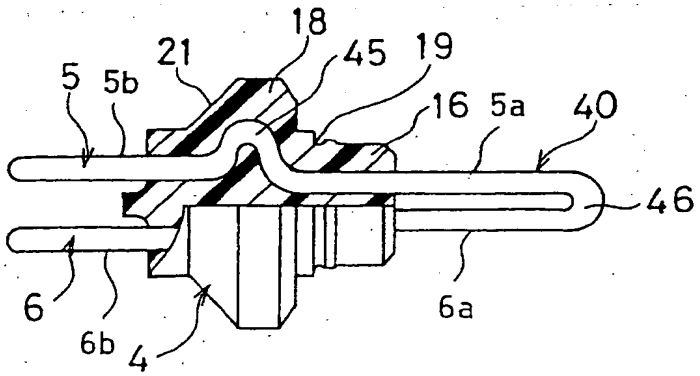


FIG. 5(a)

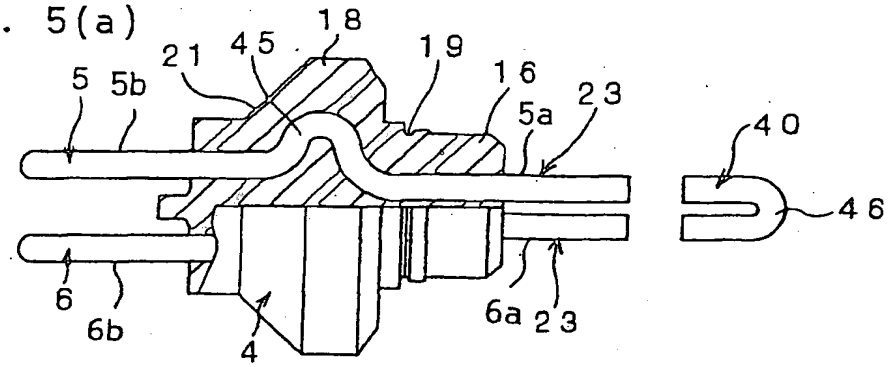


FIG. 5(b)

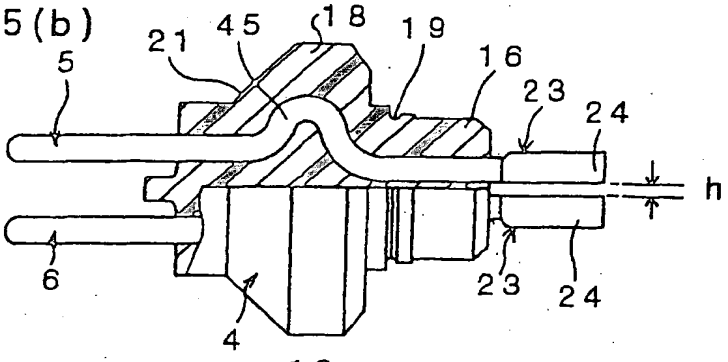


FIG. 5(c)

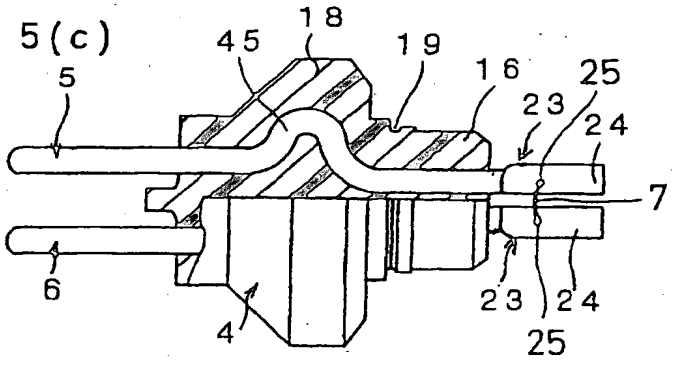


FIG. 5(d)

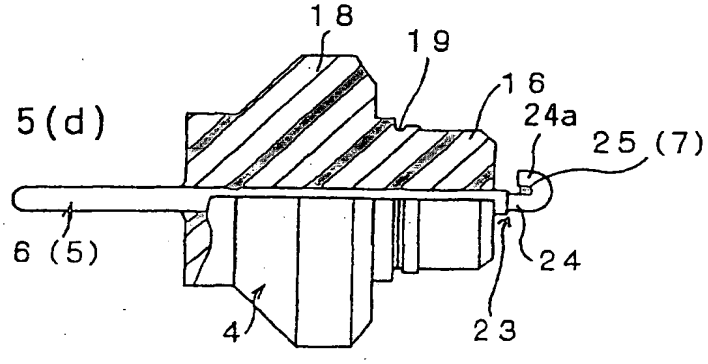


FIG. 6(a)

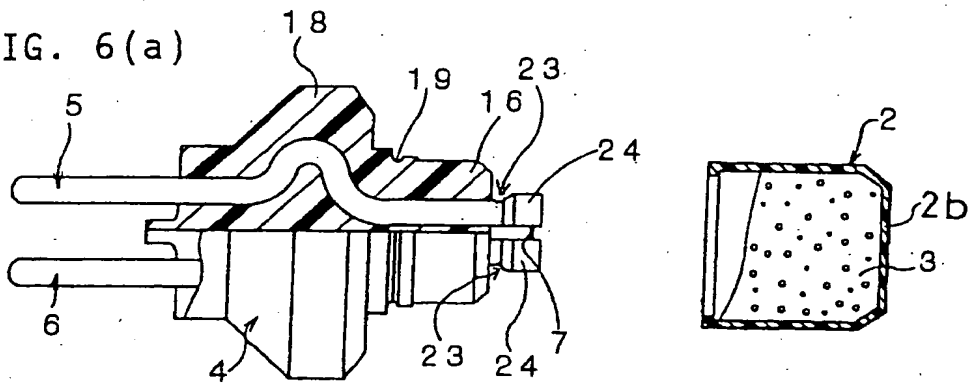


FIG. 6(b)

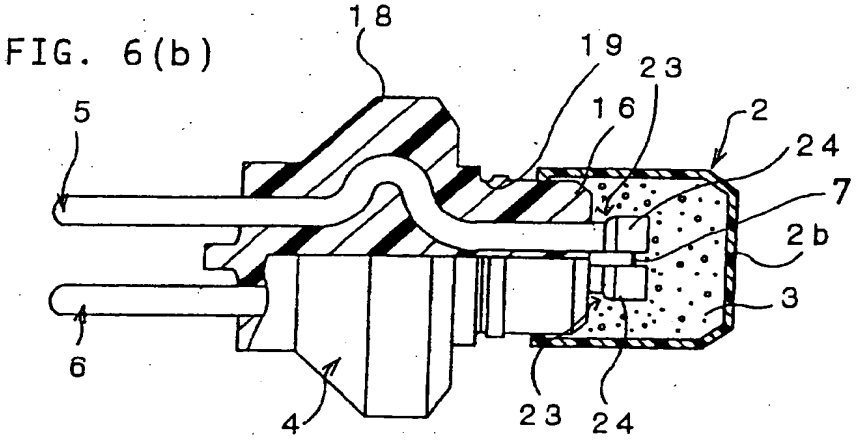


FIG. 6(c)

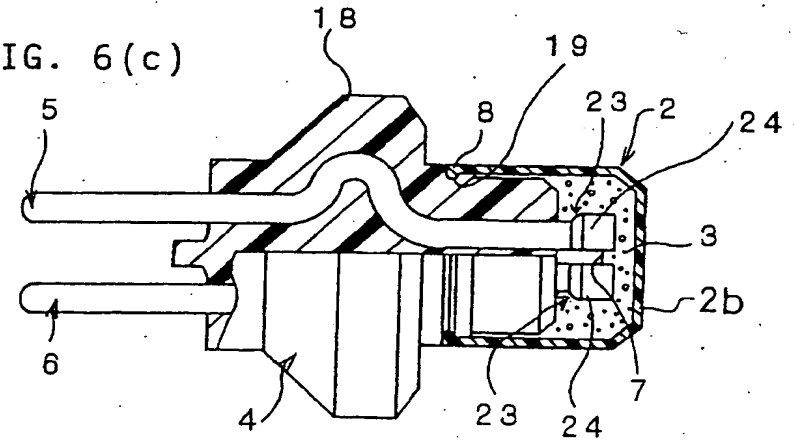


FIG. 6(a)

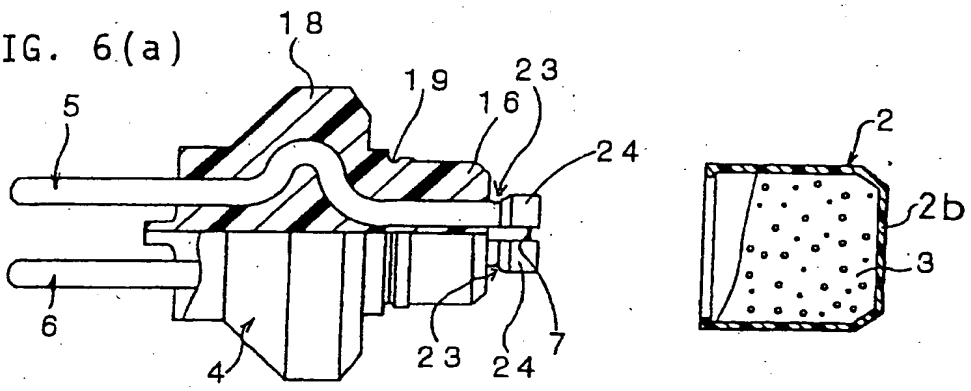


FIG. 6(b)

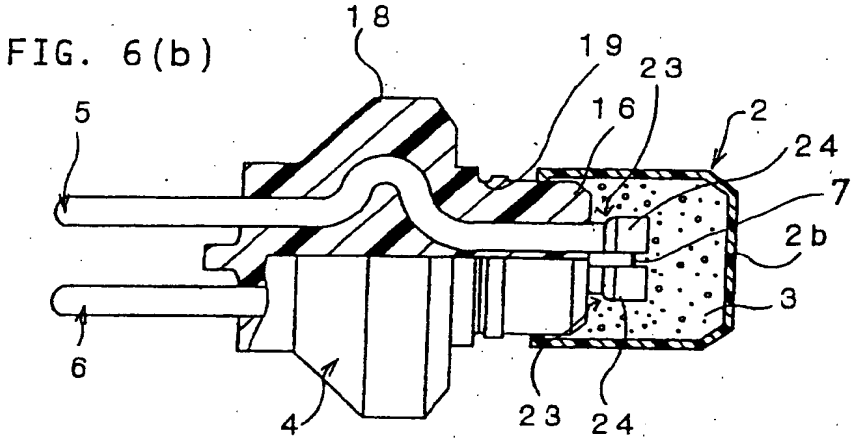


FIG. 6(c)

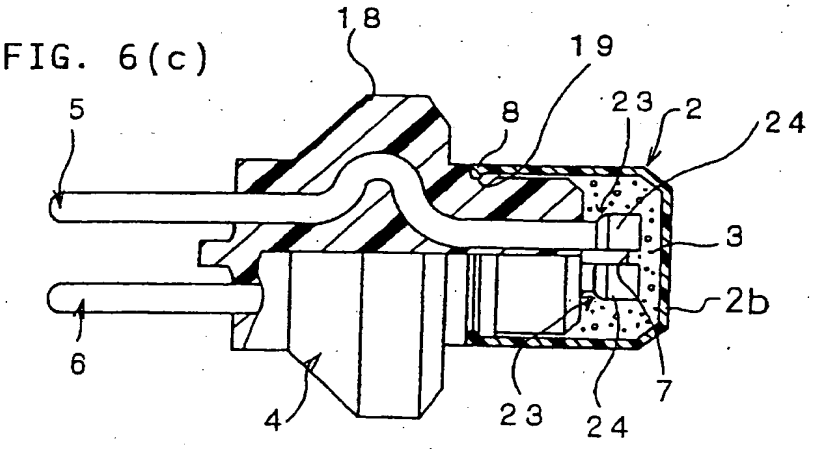
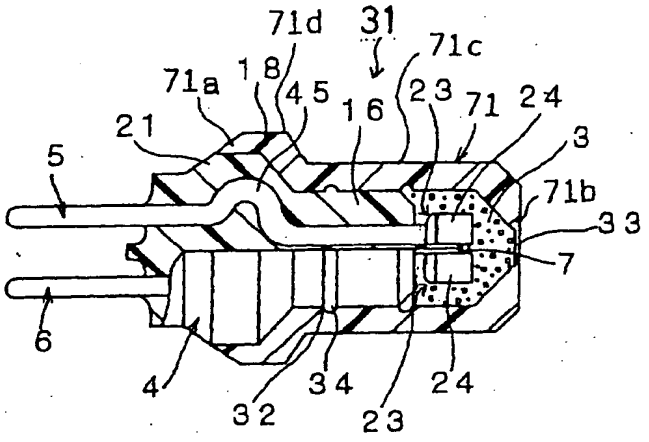


FIG. 8


71d
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71c
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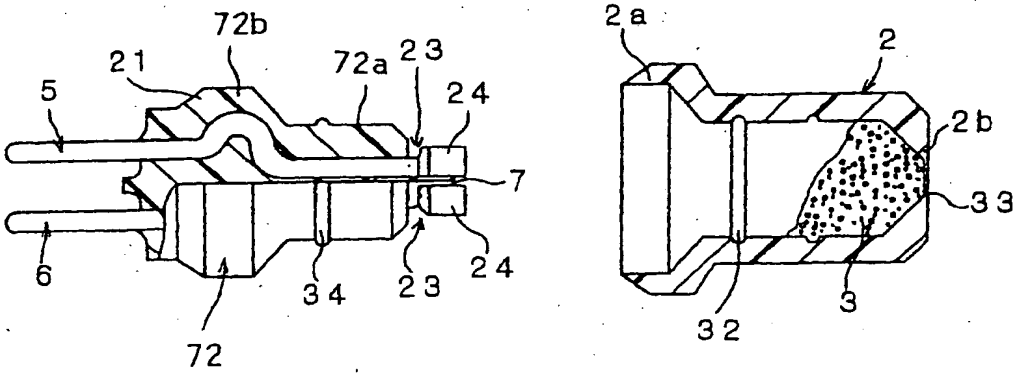
FIG. 9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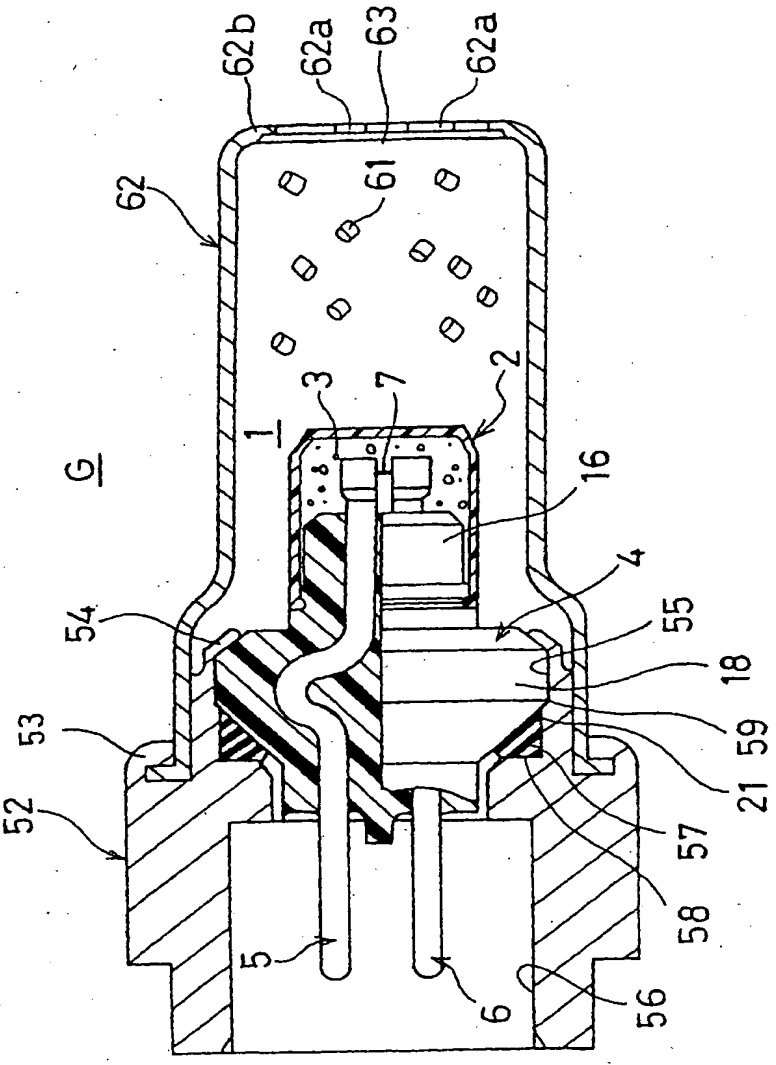

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/04338

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F42B 3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] F42B 3/12
B60R 21/16 - 21/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US, 5140906, A1 (ICI Americas, Inc.), 25 August, 1992 (25.08.92), Column 3, line 20 to Column 4, line 33 (Family: none)	1-6,10,11,12 9,13-15 7,8
Y	JP, 3058511, U (Morton International Inc.), 10 March, 1999 (10.03.99), Par. Nos. 38, 45 to 46 & US, 5932832, A & EP, 802092, A1	9,13-15
A	DE, 3837332, A1 (Leopold Kostal GmbH & Co KG,), 10 May, 1990 (10.05.90), Fig. 1 (Family: none)	7,8
A	JP, 3038722, U (Morton International Inc.), 09 April, 1997 (09.04.97), Figs. 1 to 3 & US, 5672841, A & EP, 779492, A3	7
A	US, 5798476, A1 (TRW Inc.), 25 August, 1998 (25.08.98), Fig. 4 (Family: none)	7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August, 2000 (23.08.00)	05 September, 2000 (05.09.00)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/04338

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 3028182, U (Morton International Inc.), 12 June, 1996 (12.06.96), Figs. 7, 9, 10, 13 & US, 5496062, A	7

Form PCT/ISA/210 (continuation of second sheet) (July 1992)